VOLUME XXXI NUMBER 7 WHOLE NUMBER 266

THE JOURNAL

OF

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

EDITOR, C. A. CHANT ASSISTANT EDITOR, F. S. HOGG
David Dunlap Observatory
Richmond Hill P.O., Ont.

ASSOCIATE EDITORS

R. MELDRUM STEWART
Dominion Astronomer
Ottawa

W. E. HARPER
Director of the Dominion Astrophysical Observatory
Victoria, B.C.

J. PATTERSON
Controller of the Meteorological Service of Canada, Toronto

PUBLISHED MONTHLY
(*Ten numbers per year*)

September, 1937

PRINTED FOR THE SOCIETY
TORONTO: 198 COLLEGE ST.

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

VOL. XXXI, No. 7 SEPTEMBER, 1937 WHOLE No. 266

Articles PAGE

A Projection Machine for the Measurement of Astronomical Spectra (with Plate VIII) ..... *R. M. Petrie* 289
Meteor Photography ..... *P. M. Millman* 295
Corneal Reflex Test ..... *H. S. McClung* 311
Radio Talks over CFCT, Victoria, B.C.: The Lowell Observatory .... *W. E. Harper* 314

Meteor News

Preliminary Report on the Perseid Meteors in 1937—The Fireball of June 23, 1937 ..... *P.M.M.* 317

Review of Publications

Essentials of Engineering Astronomy, by Jerry H. Service, (*F.S.H.*) 319

Notes and Queries

Changes in Lunar Craters Messier and Pickering (*F.S.H.*)—Comets Finsler and Hubble (*F.S.H.*)—June Report of Variable Star Observers, Toronto (*F.S.P.*)—Notes from Dominion Astrophysical Observatory (*W.E.H.*)—Poetry, Science, Prose (*C.A.C.*)—Summer Pickings (*C.A.C.*) 320

Meetings of the Society

At Victoria—At Vancouver—At Montreal—At Hamilton—At Ottawa —List of New Members at Large 329

Upon request, made previous to publication of article, contributors will be supplied free with twenty-five copies of the sheets containing the article attached to a printed cover.

If separate reprints are desired the cost will be about as follows:

	4 pp.	8 pp.	12 pp.	16 pp.	20 pp.	24 pp.
50 copies....	$3 50	$5 50	$9 50	$10 00	$13 00	$16 00
100 copies....	4 00	7 00	10 00	11 00	14 00	18 00
200 copies....	4 50	8 00	11 00	12 00	15 50	20 00

Covers, extra, 50 copies, $1.50; 100 copies, $2.00; 200 copies, $2.50.

Business correspondence, remittances, etc., should be addressed to J. H. Horning, Treasurer of the Society, 198 College Street, Toronto.

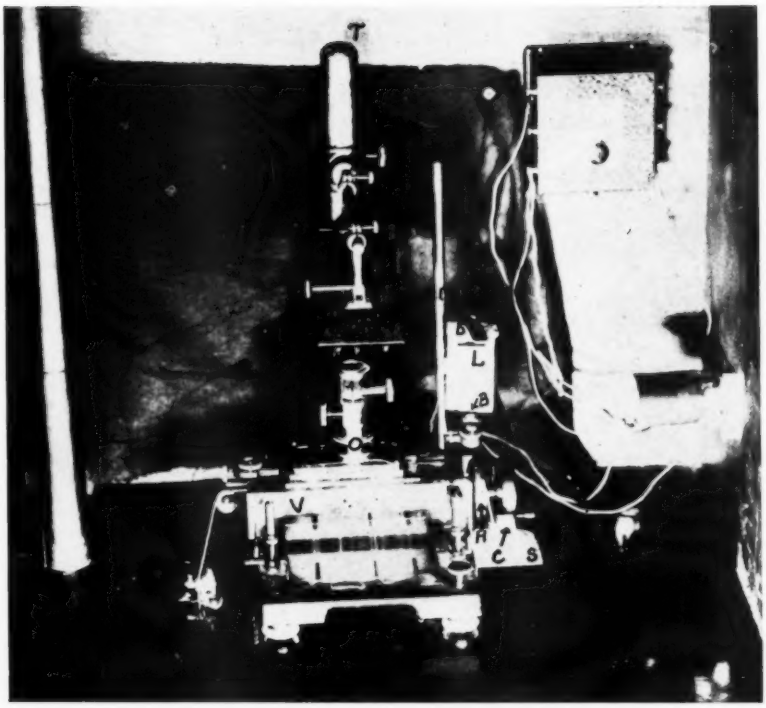
Communications regarding Library matters should be addressed to the Librarian.

$2.00 per annum. Single numbers, 25 cents.

Subscription to the JOURNAL is included in membership fee.

For Sale—12¼-inch reflector, a splendid instrument, pyrex disc, right angle prism, etc. Price $350.00. For particulars and photos, write Fred E. Lewis, Vernon, B.A.

PLATE VIII.



The Projector Micrometer as it appears in use.

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY
OF CANADA

Vol. XXXI, No. 7 SEPTEMBER, 1937 WHOLE NO. 266

A PROJECTION MACHINE FOR THE MEASUREMENT OF ASTRONOMICAL SPECTRA

By R. M. PETRIE

With Plate VIII

AN important part of the activities of the modern observatory is the precise measurement of the positions of absorption lines in photographed stellar spectra. The determination of wave-lengths for purposes of identification of elements, the measurements of radial velocities leading to a knowledge of the motions of the sun and other stars and the detailed study of orbits of binary systems, are all based upon positional measures made from relatively small scale spectrograms. The usual procedure is to view the spectrum through a microscope equipped with a reticle, while the plate is moved by means of a screw with a divided head serving as the micrometer. While this method is capable of yielding results of high accuracy, the eye-strain involved produces a fatigue, well known to those engaged in the determination of stellar radial velocities, which limits the expedition of a large programme of measurement. The measurements of stellar spectra for radial velocities constitute a large part of the work of this observatory; it was decided to construct and test a machine designed to reduce eyestrain and promote efficiency in measurement. The natural tendency was to favour a method of projection since this method has been used successfully in related problems. A projection comparator for the measurement of laboratory spectra has been described by Backlin[1] and others; the application of a projection method to the measurement of parallax plates has been made by Schlesinger and Bennett;[2] and the method has

[1] *Rev. Sc. Instr.* **1**, 662, 1930.
[2] *M.N.* **93**, 382, 1933.

been applied to measurements of lunar photographs by McMath, Petrie and Sawyer.[3]

The machine constructed for use in this observatory bears a general resemblance to some of those previously described. In adapting an existing machine the chief object was the elimination of fatigue and to this end the following principles were adopted, (a) the operator should not look through an optical system, to observe either the spectrum or the scale reading, and (b) the projected image of the spectrum and that of the scale reading, and the recording sheet, should be approximately in a plane and situated as closely together as would be practicable. These conditions, which avoid frequent changes in the reading distance of the eye, have been incorporated in the machine without increasing the time, or decreasing the accuracy, of measurement.

The machine was constructed by adapting a conventional microscope micrometer by Gaertner. The screw has a pitch of ½ mm. and the micrometer head is divided into 500 parts, the whole revolutions of the head are read from a fixed linear scale. This instrument with the microscope removed, but otherwise intact, served as a nucleus for the projector. The essential parts are shown diagrammatically in Figure 1, which is drawn to illustrate the arrangement of the optical systems. The micrometer, with divided head H, is bolted to a heavy iron casting which also supports the tube T for carrying the optical parts, the viewing screen V upon which the enlarged image of the spectrum is projected, and the screen S upon which an erect magnified image of the index and adjacent portion of the micrometer head is focussed. This latter feature is similar in principle to a device employed by Harrison,[4] by means of which the scale reading is photographed upon motion picture film.

The source of light is a 250-volt projection lamp used with two condensing lenses as shown in Figure 1. This arrangement allows one to place the lamp at some distance from the mechanical and optical parts, thus reducing disturbance due to local heating. The lamp-house is provided with a vertical flue placed 16 inches from

[3] *P.O.* Univ. Mich. VI, 67, 1935.
[4] *J. Opt. S. Amer.*, **25**, 169, 1935.

the optical axis of the machine and heating effects are found to be inappreciable in this case. The projection system consists of the microscope objective *O*, of which three are available, and the plane mirrors *M*. The objective tube has a rack-and-pinion motion for

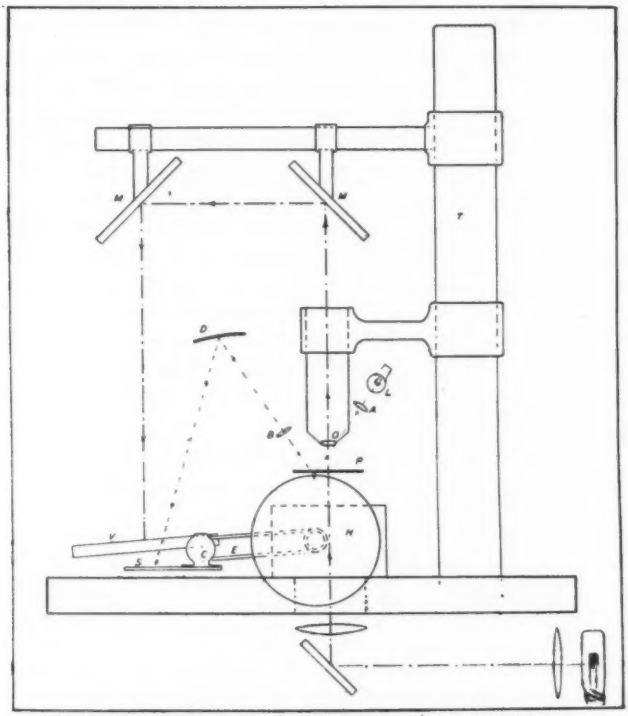


FIG. 1 PROJECTION MICROMETER (DIAGRAMMATIC)

focussing and its supporting bracket may be moved on the brass tube. The plane mirrors *M* may be tilted and they also slide and rotate on their supporting arm which may be moved up and down the brass tube *T*, giving a rapid means of varying the magnification.

The scale of the projected image may be varied by a factor of two in this manner.

The viewing screen is a piece of white marble and the recticle is a fine black wire in contact with the screen. A piece of white paper with a fine ruled line serves as a satisfactory alternative. The viewing screen cell has horizontal and vertical motion and may be tilted to suit the convenience of the measurer. The reading of the divided micrometer head is projected upon a small screen placed beside that used for viewing the spectrum. A spot of light is focussed upon the micrometer head by means of the lamp *L* and condensing lens *A*. The lens *B* and concave mirror *D* then give an erect image of the index and adjacent section of the micrometer head, magnified approximately 20 times. A dim reading lamp above the recording pad and the six-volt lamp *A*, are fed by a transformer with variable-voltage control. An additional convenience is the revolution-counter *C*, which shows the integral part of the reading immediately beside the micrometer-head image. The counter is provided with a pulley and is driven from the shaft of the screw by a spring-belt *E*. After several trials it was found to be possible to minimize the "creep" introduced by the spring-belt, through unequal pulleys on shaft and revolution-counter.

Three objectives are available for projection of the image of the spectrum, giving the following ranges in magnification.[5]

Objective	*Magnification*
Low Power	11 to 21 diameters
Intermediate "	18 to 35 "
High "	27 to 47 "

The objective of intermediate power is usually employed and one rarely requires magnifications beyond its range. A photograph of the machine as it appears in use is given in Plate I, the principal features mentioned in the description being indicated.

This instrument has been in use for several months and has proved to be quite satisfactory. A comparison of radial-velocity

[5]These are the effective magnifications assuming a distance of 15 inches from eye to screen.

measures on this and microscope micrometers indicates that the errors of measurement are of the same order in the two cases. The comparison has been made by measuring a number of spectra on the projection machine and on a microscope micrometer, probable errors being derived from the internal agreement of the individual lines. These results are shown in the following table, the columns in order giving the name of the star, spectral class, number of plates compared, average number of lines measured on a plate, the probable errors using the microscope and those found using the projector. The quantity r_o is the average of the probable errors of the velocity of a single plate while r_a is the average of the probable errors of a line of average weight. With the exception of the second line under π^5 Orionis, all plates are made with our IM dispersion, axxproximately 30 angstroms per millimetre, so that the values of the table reduce to millimetres, if multiplied by 0.0005. The writer is indebted to Dr. A. McKellar of this observatory for the measurements on δ^1 Lyrae.

COMPARISON OF PROBABLE ERRORS

Star	Type	Plates	Lines	Microscope		Projector		Dispersion
				r_o	r_a	r_o	r_a	
				km/sec.	km/sec.	km/sec.	km/sec.	
H.D. 199140	B1s	10	8	±3.6	±9.6	±3.3	±8.9	I Prism
π^5Orionis	B2s	7	10	2.0	6.0	1.7	5.4	I "
π^5Orionis	B2s	5	12	1.3	4.3	1.3	4.1	II "
δ^1Lyrae	B3	6	8	4.0	11.5	3.8	10.8	I "
σCygni	Aop	6	9	1.5	4.6	1.4	4.0	I "
H.D. 109510	A3	8	8	2.3	6.1	2.2	6.0	I "

It will be observed that the results of this comparison indicate that the projection method yields results of the same degree of accuracy as those of the microscope micrometer, although a better comparison will be possible when a greater number of plates are available. This result applies principally to spectra in which the lines are well defined. The apparent contrast in the projected image is slightly less than that of the plate as viewed through a

microscope, and this may decrease the usefulness of the projection method in the study of A- and B-type spectra with unusually diffuse lines.

A considerable improvement in the ease of measurement has resulted from the adoption of the projection method since the operator is relieved of the necessity of looking through optical systems, and of reading features and scale divisions at different eye-distances. The projected spectrum image, the projected micrometer-head image, the revolution-counter and the recording pad are situated closely together and at practically a uniform distance from the eye. The consequent decrease in fatigue is marked, resulting in increased efficiency and speed, considerations of some importance when an arduous programme of radial-velocity determinations is being prosecuted. A secondary advantage of the projection method lies in the fact that several persons can examine and discuss a spectrum, or spectral feature, simultaneously.

SUMMARY

(1) An optical system for the projection of astronomical spectrograms at high magnifications has been devised. This has been designed for use with the type of micrometer ordinarily used in observatories.

(2) An enlarged image of the micrometer-head readings has been projected beside the projected spectrum image.

(3) A decrease in the fatigue of measurement has resulted from the use of the projection method, without any loss in the accuracy of measurement.

Dominion Astrophysical Observatory,
Victoria, B.C.
July, 1937.

METEOR PHOTOGRAPHY*

By Peter M. Millman

THE amateur astronomer who possesses a good camera often wishes to know some way in which he can use it in the definite advancement of astronomical knowledge. A programme of meteor photography provides the surest means by which valuable results may be obtained, while in no way duplicating the work done at the large observatories. Meteors being local phenomena in the earth's atmosphere, thousands of stations located all over the United States and Canada could simultaneously carry out a programme of meteor photography, and the value of the work carried out at each station would actually increase with the number of stations similarly engaged. This is not true of any other branch of astronomical photography. When we add to this the fact that in meteor photography lenses of very modest aperture are the most efficient, and that an equatorial mounting and driving clock are not necessary, we see that it is really the ideal field for the enthusiastic amateur photographer. However, in general, meteor photography has been woefully neglected in the past, perhaps because it requires more perseverance than most other branches of astronomical study. It is impossible to secure meteor photographs at will, in the way we photograph other objects. Even assuming that we have the requisite instrumental equipment and a clear sky at the time of observation, the success or failure of the programme depends to a great extent on luck. And yet it is this very element of chance that adds zest to the work, and when one does secure a really fine meteor photograph it occasions a thrill which is totally lacking in the more standardized branches of astronomical photography.

Let us consider the best type of lens to use in photographing the elusive meteor. In stellar photography we have point sources of light and the actual aperture of the lens, that is, its light gathering power, is of prime importance. In direct meteor photography we have a source which is effectively a line with no thickness. Here, as Õpik has shown (*Harvard Bulletin* 879, p. 5, 1930) it is the aperture ratio (ratio of focal length to aperture) which is the chief factor in determining the efficiency of the lens; approximately, the

Reprinted from "Amateur Telescope Making, Advanced," published by Scientific American Publishing Co.

efficiency varies inversely as the square of the aperture ratio. The absorption and reflection of light by the glass of the lens, however, must be taken into account, and since one never knows where the next meteor will appear, the chance of photographing one varies directly with the area of the field covered by the lens. It is because of these last named considerations that the lens with the smallest aperture ratio is not always the most efficient for meteor photography. A highly corrected F/3.5 lens usually has a much greater total thickness of glass and a much smaller field in good focus than the corresponding F/4.5 lens. A lens for meteor work should have a field 30 or 40 degrees in diameter in really excellent focus. Lenses such as the Zeiss Tessar or Voigtlander Skopar, of aperture ratio F/4.5 and focal lengths ranging from 4″ to 10″, have been found excellently suited to meteor photography. As in all astronomical work, permanence of the record and adaptability to accurate measurement are of the greatest importance and a plate camera is much to be preferred to one taking only roll-film.

Focusing the camera is best done by trial and error. If there is an infinity mark on the camera, use this as an approximate focus; if not, then focus roughly on a distant object by means of a piece of ground glass. Successive exposures on the stars of from one to five minutes can now be made on a clear night, setting the focus at several positions on either side of the approximate point previously determined. If the camera is kept stationary the stars will trail, and by making the exposures of different lengths each will be identified and thus only one plate need be used. When this has been developed the exposure with the best focus can be determined. Sometimes it is wise to make a second focus test using a smaller range of settings on either side of the focus determined by the first test. A small eye lens giving a magnification of 6 to 10 diameters will be found necessary for examining the focus tests. The camera should now be fixed firmly at the position of best focus, ready for use on some night when a large number of meteors is expected. A tilting top, or a mounting by which the camera may be firmly held when turned to any part of the sky, is necessary for the best results. A meteor will generally photograph as a straight line of varying density and may lie at any angle on the plate. The stars will all appear as trails which approximate segments of circles centered at

the north celestial pole. A guided plate will show the stars as dots and is of course much finer for show purposes, though the scientific value of the meteor photograph is not increased. There is no objection to mounting the meteor camera on an equatorial mounting provided that this is without vibration and a good driving clock is available. Guiding entirely by hand with slow motion is not recommended, as a slight irregularity in motion might occur just as a bright meteor crossed the field of the camera. This would introduce a spurious irregularity into the meteor path and render it useless for accurate reduction. With a perfectly dark sky, away from city lights and haze, and a lens of aperture ration F/4.5, most types of plates may be exposed for an hour without showing too much sky fog. Near lights, or with a moon, the exposure time should be reduced to 30 minutes or even 15 or 10 minutes where the sky is very bright.

In the above I have been speaking only of the direct photography of meteors. The photography of meteor spectra is more difficult but proportionately of much greater value to astronomy. Up to the close of 1935 only 39 meteor spectra had been photographed and some of them are faint and show very little detail. (*Jour. R.A.S.C.*, Vol. 28, p. 279, 1934; Vol. 29, p. 241, 1935; Vol. 30, p. 249, 1936.) Although meteor spectrophotography is by no means "simple and easy" in the accepted sense of the words, it presents no serious difficulties to the experienced photographer or to the telescope maker who has really used his instrument for an observational programme. The small number of meteor spectra photographed to date is due chiefly to the fact that, until fairly recently, scant attention has been paid this subject. The assistance which the amateur can render in this field is demonstrated when it is realized that nearly half the meteor spectra photographed in the last few years have been secured by amateurs. The Texas Observers of Ft. Worth have alone contributed seven. Meteor spectra are of great value not only in the study of the meteors themselves but in revealing atmospheric conditions at heights where meteors are visible, from 25 to 100 miles above the earth's surface.

What is the instrumental equipment necessary for meteor spectrophotography? In addition to a lens of the type used for direct photography one needs a prism of glass or quartz of high

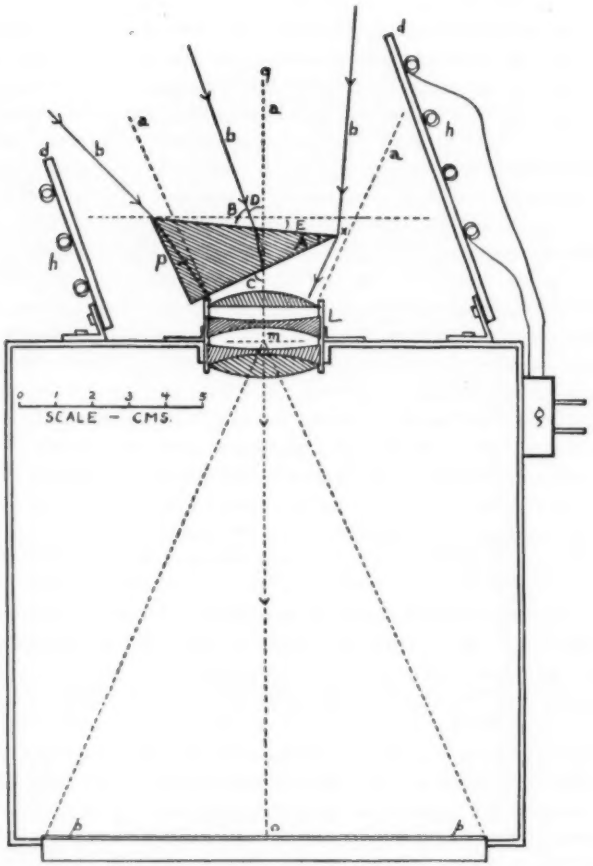


Figure 1—Diagram showing the arrangement of the essential parts of a meteor spectrograph utilizing an F/4.5 lens of 135 mm. focal length and a 30° prism. P, prism; L, lens; oq, optical axis of lens; om, focal length of lens; pp, photographic plate; dd, dew cap; hh, heating coils; g, electric plug for heating coils; aaa, pencil of rays which enters the lens when it is used without a prism; bbb, pencil of rays which enters the lens when it is used with prism.

optical quality and somewhat larger than the lens. For best results the refracting angle should be about 30°. Small angles give too small a dispersion; and, while angles as large as 45° can be used, the glass absorption greatly cuts down the speed of the optical system. The prism is mounted firmly in front of the lens and as close to it as convenient (see Fgure 1). The position should be one of minimum deviation, that is, the rays of light should pass symmetrically through the prism so that angle C equals angle B. The prism will be in the correct position if the front surface is set at an angle E to the plane of the plate or lens, where $E=(A-D)/2$, and the thin edge of the prism is nearest the lens when E is positive. A is the refracting angle of the prism; D, the angle of minimum deviation, may be found to the required degree of accuracy by setting the prism on edge on a large piece of white paper on which has been drawn a single straight line and then studying the way the light is bent by observing this line through the prism. The exact angle at which the prism is set, however, is not nearly so important as making sure that the prism is firmly mounted so that its position with respect to the lens will not vary in the slightest throughout the course of the observation. This last point cannot be too strongly stressed. The prism must be larger than the lens to include the entire pencil of light a, a, a. Since the thin side of the prism is very much more transparent than the other the position of maximum efficiency for any one prism will generally be found to be one where a small portion of the pencil a, a, a is not covered, as at x in the figure. To avoid troublesome direct images on the plate this space should be masked out, while care is taken not to cut off any light entering the prism.

At most stations in Massachusetts and Ontario, where the writer has carried out photographic programs, considerable trouble has been encountered with dew and frost which have an unpleasant habit of condensing on the prisms and lenses. To avoid disappointment the meteor photographer is strongly advised to equip his cameras with some type of heating arrangement. A very convenient form consists of coils of resistance wire wrapped around an insulated dew cap. At the Dunlap Observatory heaters consisting of 50 to 60 feet of Chromel C wire No. 25 are used. The wire is wound into a tight coil about an eighth of an inch in diameter

and then this coil is stretched around the dew cap in a helical form. The total resistance of such a heater is 40 to 50 ohms and when one or two carbon lamps are placed in series with it it can be plugged into the standard 110-volt circuit. The resistance of the circuit should be adjusted so that the heater feels just slightly warm to the hand when the camera is in the laboratory. In the writer's experience no trouble at all with dew or frost has been encountered since these heaters were installed. If several cameras are used simultaneously the heaters can all be arranged in series and very little added resistance will be found necessary.

The adjustment of the focus for a meteor spectrograph is performed in the same way as for direct cameras, except that in this case the prism spreads the light into a spectrum, so that the star trails are not sharp, even when in focus. For this reason the focus must be judged by the sharpness of absorption lines in the stellar spectra. The Balmer series of hydrogen is the best for this purpose; Sirius in winter and Vega in summer are convenient stars to use since they are bright and show the hydrogen lines very strongly. It must be remembered that a prism disperses the light in a direction perpendicular to its thin edge. To obtain spectra of the highest quality the star should trail approximately at right angles to the dispersion, in other words, parallel to the thin edge of the prism. Similarly, when exposing for meteors, the camera should be turned so that the thin edge of the prism is parallel to the most probable direction of flight of the meteors. This is important since the spectrum of a meteor crossing the field exactly parallel to the dispersion cannot be photographed. It is also important to secure a few spectra of a star like Sirius when the camera has been finally adjusted. They will serve as dispersion standards and make possible the complete study of any meteor spectra photographed.

In spectrophotography, even more than in direct photography, the nominally fastest lenses are not always the best, for here good definition is absolutely essential or much spectral detail is lost. To photograph one meteor spectrum in good definition is far more important than to secure ten that are of only fair quality. In the experience of the writer, lenses faster than F/4.5 do not have the requisite definition over a wide enough field for efficient meteor spectrophotography. The longer the focal length the greater the

dispersion possible with a prism of given angle, but also the greater the glass absorption of both prism and lens. A practical range of dispersions for this work is from 0.5 to 1.5 mm. from Hβ to Hγ. With an F/4.5 lens of 25 cm. focal length the most efficient prism over the whole photographic range is one of ultra-violet crown (Jena glass number UV 3199), angle 30° to 40°. Almost as good in all but the short wave-lengths is a 20° to 30° prism of light flint (Jena glass number *O* 340 or *O* 602). To get sufficient dispersion with a lens of 13.5 cm. focal length the light flint should be used, the prism angles ranging from 30° to 40°.

The specifications for a prism to be used in meteor photography are not quite as exacting as is the case for some prisms used in laboratory work. The chief requirement is that there be two plane surfaces of adequate size and high optical quality ($\lambda/8$ to $\lambda/10$, say) but the exact angle between these two planes is of no consequence nor is the position of their line of intersection. Only two faces of the prism need be optically ground and polished, all the other surfaces being rough ground. Satisfactory prisms of such a character have been secured at reasonable rates from the firm C. P. Goerz, Am. Optical Co., 317 East 34th St., New York City.

A question may arise here as to the possibilities of the new Schmidt cameras in the field of meteor photography. They may prove very useful in the direct photography of meteors because of their tremendously fast aperture ratios. They may not be particularly suited to meteor spectrophotography because, apart from the smaller field in good focus, there is another and greater difficulty. To secure adequate dispersion in a camera of 6″ focal length a prism of about 30° refracting angle is required. But a Schmidt camera of aperture ratio F/1.0 has an objective 6″ in diameter and a 30° prism large enough to cover this would have a prohibitive light absorption (and probably a prohibitive cost as well). The rate at which the prism size increases with the size of the objective is rather alarming. If the camera is made of very short focal length then the dispersion is too small to be useful.

The accompanying illustrations show the results that can be obtained with modest equipment. In figure 2 is a meteor spectrograph with the heater and dew cap removed so that the position of the prism in front of the lens may be seen. The camera is a

Voigtlander Avus with the F/4.5 Skopar lens of 135 mm. focal length taking a plate 9 by 12 cm. in size. The prism is by Hilger, of silicate flint glass, with a refracting angle of 30°. The two meteor spectra reproduced in figure 3 were photographed with this instrument and clearly indicate the fact that large and very expensive instruments are unnecessary in meteor photography. In each case the meteor crossed the field of the camera almost per-

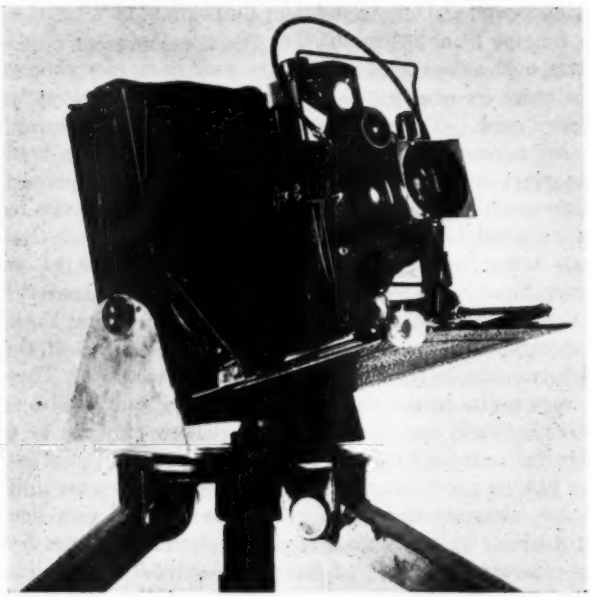


Figure 2—Meteor spectrograph, shown without dew cap and heater.

pendicular to the direction of the dispersion. It will be seen that the light of meteors is similar to that of a glowing gas, the spectrum consisting of many bright lines with little evidence of a continuous spectrum. The two spectra illustrated here represent the two chief types observed: Type Z, which contains in the main the atomic lines of iron, and Type Y, which exhibits in addition to the iron

two very strong lines in the violet, the H and K lines of ionized calcium. Type Z in general seems to correspond to the lower meteors and probably represents the slower objects that penetrate

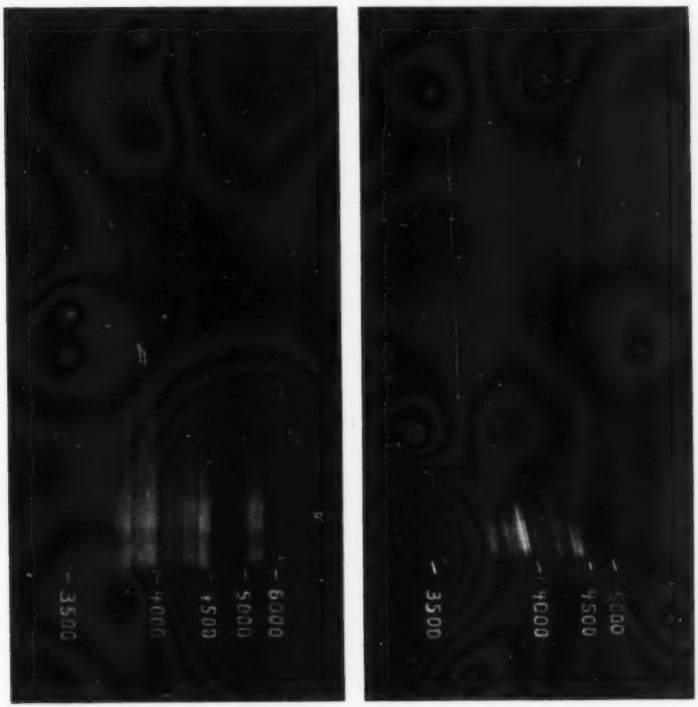


Figure 3—Typical meteor spectra. Left: Type Z—Nov. 18, 1935, Dunlap Observatory, Richmond Hill, Ont. A blue Leonid as bright as Venus. Taken on Ilford Meteor Pan plate. Wavelengths given in angstroms. Right: Type Y—Dec. 15, 1931, Blue Hill Observatory, Mass. Orange sporadic meteor of the brightness of Jupiter. Taken on Cramer Hi-Speed plate. Wavelengths given in angstroms.

below a height of 50 miles. (For a more complete discussion of meteor spectra see *Harvard Annals*, Vol. 82, pts. 6 and 7, 1932 and 1935).

A rotating shutter, driven by a synchronous motor, so mounted that it completely covers the lens 10 to 30 times a second, is a valuable accessory. The resultant meteor trail will thus be broken up into segments, and not only the angular velocity of the meteor can then be computed but the segmented trail will indicate the ratio of the instantaneous luminosity at any one point to that of the enduring train, or else it will demonstrate that the latter was not strong enough to impress itself on the plate. A meteor spectrograph equipped with a rotating shutter will reveal the nature of the spectrum of the persistent train where this has an intensity great enough to show on the photograph. (*Jour. R.A.S.C.*, Vol. 30, p. 101, 1936).

The choice of plates for both kinds of meteor photography is of extreme importance. In direct photography we have a single image, and the entire sensitivity of the plate is applied to building up the intensity of this one image. A fast panchromatic plate is usually the most satisfactory, as it is sensitive over a wide range of wave-lengths which materially increases the speed, especially as many meteors are of a decided yellow or orange colour. In spectrophotography we have a large number of images corresponding to a single meteor, each image representing a different colour or wavelength; it is the maximum sensitivity of the plate in each of several colours that we are interested in, and no one type of plate is fastest in all regions of the spectrum. For example, the Cramer Hi-Speed plate is extremely fast in the blue region and well suited for spectrophotography in the range $\lambda 3800 - \lambda 4800$, but is not generally so fast as a good panchromatic plate for direct photography. The Cramer Iso-Presto has almost the same blue sensitivity plus a band in the yellow-green but it is not as clean working as the Hi-Speed and gives considerably more sky fog. The Ilford Astra II plate is another very good ortho plate with high blue sensitivity. To the writer's knowledge the first attempt to specially sensitize plates for meteor work was made by the Ilford Company at the request of Mr. J. D. Williams, then of Tucson, Arizona. The result was a specially sensitized Hypersensitive Panchromatic plate which proved to be very fast when tested but seemed to have unreliable keeping qualities. This plate was later developed into the Ilford Meteor Panchromatic plate which has now been renamed Astra IX.

The writer uses the Astra IX regularly for meteor spectrophotography. It is characterized by a high speed emulsion with relatively fine grain and a very even gradation of sensitivity through the blue and visual regions, a maximum at about λ 6000 and a sensitivity down to about λ 6500 for good exposures. Though more satisfactory as regards keeping qualities than the earlier emulsions it is advisable not to store the Astra IX too long and, like all panchromatic plates, it probably keeps better in a refrigerator. The Ilford Hypersensitive Panchromatic plate is another very fast emulsion, especially suitable for direct photography. Successful photography of meteor spectra in the red has also been carried out with the Eastman I C Special Spectroscopic plate. This carries a little farther into the red than the Astra IX but has a much lower sensitivity in the green and in general has been found to have rather large grain. The Eastman Super-sensitive Panchromatic emulsion is very suitable for the direct photography of meteors, as is the Imperial Eclipse Ortho soft plate. The above remarks are meant to serve only as a rough guide in the selection of plates. It is impossible to give a final word on the matter, and anyone taking up meteor photography seriously is advised to test frequently various emulsions against each other by making, in rapid succession, uniform exposures of 5 or 10 minutes. A determination of the faintest star trails photographed for any given declination will then give a good indication of the relative speeds of the plates when used under actual observing conditions.

We should next consider where to direct the cameras for meteor observation. The writer has investigated this question in some detail (*Proceedings, National Academy of Sciences*, Vol. 19, p. 34, 1933), and it appears that for sporadic meteors almost any region of the sky with an altitude greater than 30° is equally good, with possibly a slight advantage at altitude of around 45° for spectrophotography. The most likely direction of flight for sporadic meteors is downward, so that the prism should always be set with the thin edge vertical. In the case of observations made at the time of showers with known radiants, the region near the radiant is much the most favourable for photography, in spite of the fact that casual observations would lead one to think that the brightest meteors appear at some distance from the radiant. It is the slow

angular velocity near the radiant that makes this region richer in meteors that can be photographed. Very often a bright meteor far from the radiant appears conspicuous to the eye, which automatically follows its swift flight, while a fainter but slower meteor near the radiant would have a greater photographic effect. When the radiant is not far from one horizon, the sky near the opposite horizon is a good direction in which to point any extra cameras, after the fields within 30° of the radiant have been covered. Of course the above rules apply only to average conditions and an even distribution of meteors in space; local irregularities on any one night may greatly change the actual distribution.

The meteor photographer should make every effort to plan visual observations in conjunction with the photographic programme. This is especially necessary where stationary mounts for the cameras are used, as in this case the visual record of the time of appearance of the meteor is the only means by which the exact path among the stars can be calculated from the photographic plate. The stars trail across the plate during the exposure and they form a complete frame of reference only when it is known at what time during the exposure the meteor appeared. For the same reason it is necessary to record accurately the exact times between which the plate was exposed. By covering the lens for 5 to 20 seconds one minute from the beginning and end of the exposure, small breaks in the star trails are made which are more accurate reference points than the ends of the trails.

If it is desirable to eliminate visual observation in a long systematic programme of meteor photography the information derived from the photographic plate alone must be clearly understood. We will assume that in all cases the time of the beginning and end of the exposure is accurately recorded and that the latitude and longitude of the observing station are known. A meteor photograph secured with a stationary camera will define accurately the altitude and azimuth of the meteor but will leave its right ascension uncertain within definite limits depending on the length of the exposure. A guided plate will, on the other hand, accurately define the right ascension and declination of the meteor, while leaving its altitude and azimuth uncertain within limits. If two cameras are directed to the same field, one being stationary while the other is

guided, then the time of appearance of the meteor may be determined and its position accurately computed both with respect to the equatorial and the horizontal system of coordinates. Similarly, in a programme of height determination, where two cameras are used at either end of a suitable base line (preferably 10 to 30 miles in length), if the cameras are both stationary, then the exact path of the meteor in our atmosphere can be computed but its astronomical radiant is uncertain; if both cameras are guided the astronomical radiant is defined but the height of the meteor is not definitely known. If, however, there is a marked point on the meteor trail, such as a burst, and one camera is guided while the other is kept stationary, the radiant of the meteor and its height above the earth's surface can both be determined. Even if the meteor trail does not exhibit a marked burst the point of maximum intensity on the trail can be used, but it may be necessary in this case to make a small correction to allow for the fact that the meteor is approaching one station more rapidly than the other.

Setting up a camera and hoping that a bright meteor will cross the field covered by the lens seems a very haphazard method of conducting a scientific programme, yet it is the most practical one. It has been suggested by several that a more logical method would be to have the camera mounted on a very flexible mounting so that it could be instantly directed towards a bright meteor. While such a procedure might be successful in particular cases, in general the practical difficulties would be very great. Meteors rarely remain visible for longer than a second or two. There is no guarantee that an observer would see a meteor as soon as it becomes visible, as a very large area of the sky would have to be covered to gain any real advantage over the stationary camera. Covering this large area would also necessitate swinging the camera through long arcs. For a meteor photograph to be of definite scientific value the camera would have to be brought to a dead stop and rendered vibrationless before the shutter could be opened. In most cases the meteor would have disappeared by this time. After even two or three fruitless attempts to photograph a meteor in this way the plate would have to be changed to avoid becoming confused with the various sets of star images. The amount of photographic material consumed would thus be several times as great as if the

camera were kept stationary, and the method would almost undoubtedly prove less efficient. During the Leonid observations of 1931 the writer did have a spectrograph so mounted that it was swung away from the radiant by a small motor at the average angular velocity for the Leonids in the region of the sky covered by the lens. At the end of a swing of 30° to 40° it was quickly brought back again and the swing repeated, this see-saw motion being kept up all night. It was hoped that this would reduce the effective angular velocity of the Leonids and enable fainter meteors to be photographed. No results were obtained with this camera in 1931, though the method did not have a fair trial owing to cloudy weather. More recently Professor Whitney in California has successfully photographed a meteor spectrum with equipment arranged in a somewhat similar way (*Pub. A.S.P.*, Vol. 46, p. 279, 1934). In this latter case four spectrographs were kept in continual rotation about an axis perpendicular to the direction to the Perseid radiant. Strangely enough, the meteor photographed was not a Perseid but a sporadic meteor.

The number of meteor photographs secured in a short programme of observation is chiefly a matter of luck. As a rule any meteor as bright as Jupiter, or brighter, can be photographed with both direct and spectrographic cameras. Fainter meteors sometimes leave an image, particularly if they are of very low angular velocity. When the results of many photographic programmes are averaged up, the number of hours exposed per meteor photographed becomes more consistent. A discussion of programmes of meteor photography has been given recently in the *Jour. R.A.S.C.*, Vol. 30, p. 193, 1936, and the following table is taken from this summary. The observations of specific showers refer to those made on the three or four nights nearest the maximum date. The cameras used had lenses of speeds from F/4.5 to F/3.5 or faster and covered on the average 1200 square degrees of sky.

SUMMARY OF PROGRAMMES OF METEOR PHOTOGRAPHY

	Hours Exposed	Meteors Photographed	Hrs. Exp. per Met. Photog.
Direct Photography			
Leonids (1929-1935)	120	26	4.5
Perseids (1931-1935)	50	14	3.5
Geminids (1933)	12	3	4.
General Programmes (including shower nights)	599	29	20.
Spectrophotography			
Leonids (1931-1935)	219	11	20.
Perseids (1934-1935)	81	4	20.
Geminids (1931-1934)	119	3	40.
General Programmes (not including showers)	1351	5	270.

It will be seen that one direct photograph was secured for each four hours of exposure time during the Leonid, Perseid, and Geminid showers, and one for about 20 hours' exposure on the general programmes. The total number of hours exposed per meteor photographed is about five times as great for spectrophotography. These results may be taken as guides for future work but it must be remembered that the Leonid programmes reported above covered the last Leonid return and that these meteors will be much fewer in number during the next 25 years.

The periods of the year during which meteor photography is likely to prove fruitful are listed below. Of these the Perseids and the Geminids are the best showers for photography.

Quadrantids.....Jan. 1-3	Perseids.....Aug. 10-14
Lyrids.....Apr. 20-22	Orionids.....Oct. 18-20
Eta Aquarids.....May 3-5	Leonids.....Nov. 15-18
Delta Aquarids...July 27-29	Geminids....Dec. 10-14

Unless the amateur is prepared to lay out a good deal of money in buying photographic supplies it is hardly worth his while attempting to photograph sporadic meteors between the dates of the showers

given above. It is well worth while, however, to photograph during the shower nights when a larger number of meteors than usual is to be expected.

In closing, it should be added that meteor photography is at all times a sporting proposition and there are bound to be disappointments. It requires great patience and an ability to keep on in spite of initial failures, but if one tries hard enough and often enough, success is sure to come. To offset the disadvantage of uncertainty in meteor photography there is the knowledge that a chance bright fireball in just the right position may enable one to secure the best meteor photograph yet obtained.

The writer is always glad to answer questions or to offer what advice he can to anyone interested in meteor photography.

David Dunlap Observatory,
Richmond Hill, Ontario.

CORNEAL REFLEX TEST

By H. S. McClung

THE purpose of this article is to publish a novel and easy method of testing concave mirrors. The Foucault knife edge test is too familiar to require explanation. In it the conjugate focus of the pinhole is determined. It is somewhat difficult to find and retain the optical axis of the cone of light reflected from the mirror. Also the pinhole light is necessarily placed at the side of the observer's head, so that the axis of this light to the vertex of the mirror is at an angle with that reflected from the vertex to the observer's eye. This introduces an astigmatism which may be negligible but certainly does not tend toward that accuracy which is ideal.

To lessen the difficulty of fixation and minimize the astigmatic error, the following method is suggested. It is all stated in seven words,—"Use the corneal reflex as a pinhole".

Some further remarks may, however, be helpful. Place a small light somewhere off the line of vision to the mirror, so that it may shine upon the observer's cornea. The corneal image of the light is, of course, reflected in a multitude of directions. The mirror captures its "surfaceful" of images and re-reflects them into the pupil of the eye,—if the pupil is in the proper line. To find this proper line is easy. First place the face close enough to the mirror to see the face in the mirror, just as in a concave shaving mirror. Note the spot of light on the cornea. Now recede from the mirror, keeping that corneal reflex on the mirror's vertex. As you near the mirror's centre of curvature the spot will be greatly enlarged, filling the mirror's surface; and the slightest wavering of the head sidewise will cause the observed light to dash sidewise too. Hence care must be taken to avoid this wavering, and it is suggested that some appropriate head-rest be used. With care a point in recession will be found where a fine focogram of the mirror's surface will be obtained. If this surface is spherical it will show an even grayish light which *all vanishes at once* with the slightest movement of the cornea, the mirror, or the lamp. Pits, scratches, and all irregularities will mar the texture of the picture. The finer the grain of the polish, the finer the grain of the light will appear. If the surface is parabolic

given above. It is well worth while, however, to photograph during the shower nights when a larger number of meteors than usual is to be expected.

In closing, it should be added that meteor photography is at all times a sporting proposition and there are bound to be disappointments. It requires great patience and an ability to keep on in spite of initial failures, but if one tries hard enough and often enough, success is sure to come. To offset the disadvantage of uncertainty in meteor photography there is the knowledge that a chance bright fireball in just the right position may enable one to secure the best meteor photograph yet obtained.

The writer is always glad to answer questions or to offer what advice he can to anyone interested in meteor photography.

David Dunlap Observatory,
Richmond Hill, Ontario.

CORNEAL REFLEX TEST

By H. S. McClung

THE purpose of this article is to publish a novel and easy method of testing concave mirrors. The Foucault knife edge test is too familiar to require explanation. In it the conjugate focus of the pinhole is determined. It is somewhat difficult to find and retain the optical axis of the cone of light reflected from the mirror. Also the pinhole light is necessarily placed at the side of the observer's head, so that the axis of this light to the vertex of the mirror is at an angle with that reflected from the vertex to the observer's eye. This introduces an astigmatism which may be negligible but certainly does not tend toward that accuracy which is ideal.

To lessen the difficulty of fixation and minimize the astigmatic error, the following method is suggested. It is all stated in seven words,—"Use the corneal reflex as a pinhole".

Some further remarks may, however, be helpful. Place a small light somewhere off the line of vision to the mirror, so that it may shine upon the observer's cornea. The corneal image of the light is, of course, reflected in a multitude of directions. The mirror captures its "surfaceful" of images and re-reflects them into the pupil of the eye,—if the pupil is in the proper line. To find this proper line is easy. First place the face close enough to the mirror to see the face in the mirror, just as in a concave shaving mirror. Note the spot of light on the cornea. Now recede from the mirror, keeping that corneal reflex on the mirror's vertex. As you near the mirror's centre of curvature the spot will be greatly enlarged, filling the mirror's surface; and the slightest wavering of the head sidewise will cause the observed light to dash sidewise too. Hence care must be taken to avoid this wavering, and it is suggested that some appropriate head-rest be used. With care a point in recession will be found where a fine focogram of the mirror's surface will be obtained. If this surface is spherical it will show an even grayish light which *all vanishes at once* with the slightest movement of the cornea, the mirror, or the lamp. Pits, scratches, and all irregularities will mar the texture of the picture. The finer the grain of the polish, the finer the grain of the light will appear. If the surface is parabolic

or hyperbolic, the characteristic picture will be shown, but only experience can teach just what that picture must be to have the desired parabolism. In fact all that has been written about focograms is equally true in this test, *if* you remember that the astigmatism of oblique reflection is minimized.

It is obvious that, to avoid confusing reflexes, there should be but one light source, and that it should be brilliant. It is desirable that it should be small, but the corneal reflex is so tiny that even an ordinary light filament shows as a pinhole on the cornea. The position of the light source with regard to the line of vision is not stressed as its corneal reflex cannot be more than a few millimeters from the vertex of the cornea in any case.

In receding from the mirror, the reflected image in the mirror of the corneal reflex will move to the right if the head moves to the right,—its motion may be called a "with" motion. When you have receded past the centre of curvature of the mirror the motion is opposite to that of the head,—an "against" motion. When in your recession you reach a point where there is no motion, either "with" or "against", where the reflection from the mirror just instantly disappears, then you have found the centre of curvature of the spherical surface.

If your technique is sufficiently dexterous and your discrimination amply acute, you may determine the character of any small defective area or zone on the mirror's surface.

The knife edge technique may be employed in a manner similar to the classical method, but the knife edge can be used only from the side opposite to the source of light, because of the proximity of the corneal reflex to the pupil. If the knife edge were used on the same side as the light, the knife would cut off the light from the lamp. For the same reason the Ronchi test is not operable. However, a fine wire can be used in place of the knife edge or grating, and its projected image will give the same answers, possibly more definitely.

To determine accurately the radius of curvature of the mirror, it is necessary to recede till a definite motion "against" the motion of the head is seen, indicating recession is now beyond the centre of curvature. Then use the wire to find a point in front of the cornea where the motion of the wire's shadow is neutral. This point will

be conjugate to the corneal reflex. A simple calculation will determine that point, lying between the wire and the corneal reflex, which is the centre of curvature of the mirror.

Similar technique will determine the character of "off" areas and zones. In using it to estimate parabolism, the curvature of the wire's projected image, as it slowly progresses across the mirror, tells a lot to an experienced eye. It is in such work that delicate technique and acute discrimination are required.

Regina, Sask.
May 2, 1937.

RADIO TALKS OVER CFCT, VICTORIA, B.C.

By W. E. Harper

The Lowell Observatory

(December 22, 1936)

It was my privilege a few months ago to visit two great observatories in the Southern States and a brief description of one of them, the Lowell Observatory in Arizona, may prove of interest.

The observatory is named after its founder, Percival Lowell, one of a distinguished New England family for many years prominent in the textile industry. The city of Lowell, Massachusetts, takes its name from this famous family, and one of its members was until recently president of Harvard University. Percival Lowell was a brilliant graduate of Harvard of 1876, having specialized in mathematics. After graduation he travelled extensively in Japan and Korea before settling down to business life. He soon amassed a fortune in the textile trade but all the while was much interested in astronomy, and before he was forty he decided to give up his commercial career and devote his life and the fortune he had secured to the pursuit of astronomy.

Lowell realized that equally important with a good instrument is the location of the same. This is especially important where fine surface details of planets are to be studied and this was the work Lowell had assigned himself. It was probably the findings of the Italian astronomer, Schiaparelli, concerning the planet Mars and the possibility of life there that fired the imagination of Lowell and led him to consecrate himself to the work which through failing eyesight Schiaparelli was unable to continue. Lowell spent several years gathering data in various lands as to the best site for an observatory such as he had in mind and it was only after all possible places had been fully tested that he selected the site of his observatory at Flagstaff, Arizona.

Here in the pure air of the Arizona plateau at an altitude of 7,300 feet above sea level, Lowell found conditions to his liking. The hill on which he located is only a couple of hundred feet above the surrounding country but the desert plateau falls away gradually for miles, thus giving excellent air drainage. One would think that possibly the lights of the city of Flagstaff might affect adversely direct photography but the buildings are surrounded by a fairly heavy stand of pine timber which screens off stray illumination from the city's lights. It was brought home to me rather forcibly during my visit that they are above much of the dust and smoke which cuts down transparency at lower altitudes, for the sky at night seemed to show more contrast than that to which we are accustomed here. The Milky Way stood out much more conspicuously and evidently fainter stars can be seen with the naked eye there than is possible at our own observatory.

This does not necessarily decry our own site which was carefully selected. Flagstaff does excel ours in the transparency of the atmosphere, but in the matter of steadiness, which is the vital factor, there is probably not such a vast difference, the balance of course being in favour of the desert plateau.

Observations on the planet Mars were commenced at Lowell Observatory on May 24, 1895. We must remember that Mars is farther from the sun than we are and it receives per unit area only about one-fourth of the heat we do. Its surface temperature would average about that of a cool autumn day on our own planet. Moreover, the planet being small is not likely to retain an extensive atmosphere and from the beginning the nature of the dark surface markings were a subject for investigation. These dark regions could not be seas as the planet is devoid of large bodies of water such as rivers, lakes and oceans, while the reddish portions of the equatorial regions were considered to be desert land.

Mars moves about the sun in 687 days and has its seasons of spring, summer, autumn and winter similar to, though longer than, those of the earth. As winter comes on in its northern hemisphere a white spot gradually forms around the north polar region which as gradually disappears in the spring and reforms at the southern pole. This is thought to be akin to the snow and ice which surrounds our polar regions in the winter season and disappears in the spring. Photographs over the last forty years show the regular cycle of its appearance and disappearance and there does not seem to be much doubt that it is some form of moisture or vapour that has been frozen and lingers during the cold season.

All these photographs show dark belts covering large portions of the planet's surface which in moments of best seeing are said to break up into innumerable fine lines connected in a geometric pattern as if they were the handiwork of intelligent beings. The theory which Lowell advanced to account for these dark line-tracings is that they represent the vegetation growing up alongside the canals which the supposed inhabitants of the planet have engineered. Their purpose is to utilize the water from the melting polar caps and irrigate the arid wastes of the equatorial regions of the planet. One can understand that in a photographic exposure of even a few seconds the details would be lost and recourse must be had to the eye which registers instantly these fine details. Over a period of many years Lowell and his associates patiently observed the planet under excellent atmospheric conditions and left a wealth of drawings which convinced them at least that the geometrical pattern of lines converging to definite focal points could not be the result of pure chance. It was maintained that there must be intelligence behind the design and thus came the theory of canals to irrigate the planet.

In favour of the possibility of life on the planet it may be said that our spectroscopes reveal the presence of a very slight amount of oxygen and a trace of water vapour, two very important essentials where life is concerned. While one would hesitate to pronounce for or against the existence of life on

the planet its reality would seem to be on a not too secure basis. At the same time we recognize that Lowell and his associates were able astronomers and were sincere in all their statements.

It was my privilege to examine the 24-inch refracting telescope which is used in studies of planetary detail. They have also a 42-inch reflecting telescope, but find the smaller one much more efficient for visual work of this nature. It gives excellent definition, otherwise many of the details would be lost.

This 24-inch refracting telescope has been used in other lines of investigation as well. With a spectrograph attached to it, Dr. Slipher measured the velocities in the line-of-sight of several of the spiral nebulae and he was the first to point out how the velocities of these were invariably velocities of recession. It was years later before additions were made to these velocities and the idea of an expanding universe took hold of the astronomer's imagination.

Slipher also was a pioneer in recognizing the existence of dark matter, in an exceedingly tenuous state, scattered throughout interstellar space. This matter absorbed light from the stars and left its characteristic mark on the spectrum of the star. Later researches at other observatories including our own have shown that this widely dispersed interstellar matter partakes of the rotation of our whole stellar universe about a centre in the direction of the constellation Sagittarius.

But Lowell, and the observatory he founded and partially endowed, have received world-wide recognition not only for the studies of Mars but for the discovery of a new planet, Pluto. Lowell died in 1916 and it was not until 1930 that Tombaugh, one of the junior assistants at the observatory, recognized the planetary body while carrying out the programme which had been initiated by Lowell. The latter felt from the perturbations in the orbits of the outer planets that there must be some such disturbing body. Since he had predicted the approximate position where it would be found, the new body was appropriately named in Lowell's honour, as the first two letters of the name are Lowell's initials.

Lowell is buried in a mausoleum a few paces from the telescope with which he made discoveries that have stirred the imaginations of laymen and professional astronomer alike.

METEOR NEWS

Observations relating to meteors and meteorites are cordially invited.

Preliminary Report on the Perseid Meteors in 1937

The weather in and around Ontario was far from favourable during the week of the Perseid maximum and as a result it is likely that many stations had little or no success in making observations. Very few reports on the Perseids have been received as yet and any results at all, no matter how meagre, will be welcomed.

At the Dunlap Observatory the writer was assisted by Mr. D. A. McRae and it was possible to make some observations on three nights, Wednesday, Thursday and Friday, August 11-14, though the first of these was continually broken by heavy fog. Judging from the total number of meteors recorded visually it would seem that the Perseids this year were less numerous than in 1934, 1935 and 1936. This point cannot really be decided till the final reduction of rates for a large number of stations has been carried out.

Though the total number of meteors seemed rather lower than expected, Thursday and Friday night were each marked by the appearance of a meteor of unusual brilliance, the recorded times being respectively 12.38 a.m. E.S.T., August 13; and 12.08 a.m. E.S.T., August 14. These meteors left persistent trains visible to the unaided eye for two or three minutes and seen in small telescopes for about eight minutes. During this time the trains underwent marked changes in form resulting from the currents in the upper atmosphere. The first meteor was photographed with two cameras at the Dunlap Observatory, one spectrograph and one direct camera, and each of these was equipped with a rotating shutter. The spectrum is of Type Y and is the first example of a meteor spectrum taken with a rotating shutter. Unfortunately the meteor crossed the plate within eight degrees of the direction of the dispersion so that there is very little spectral detail shown. Visual observations from outside points have already been received and it is quite possible that other photographs of this same meteor were secured at co-operating stations. If this proves to be the case it will be one of the most completely observed meteors ever recorded.

The second meteor was photographed by Mr. M. M. Thomson at the Dominion Observatory, Ottawa, and the trail plotted with the help of binoculars at the Dunlap Observatory so that the height will be well determined. It goes without saying that any additional observations of either of these two interesting meteors will be of great value and may be sent in to this department of the JOURNAL. Three additional direct meteor photographs were also secured at the Dunlap Observatory, one of these with the rotating shutter. A more complete report of the Perseid observations will appear in a future issue of the JOURNAL.

THE FIREBALL OF JUNE 23, 1937

At approximately 8.55 p.m. E.S.T. on June 23, 1937, nearly an hour after sunset, one of the most interesting meteors recorded in Canada for some years appeared in the northwest sky. Though apparently considerably brighter than Venus, its brilliance was dulled by the twilight which was still fairly strong at the time. The persistent train, however, was very distinct and was easily seen for half an hour, and followed for fifty minutes at some places, undergoing in this period marked changes of form. The writer, though on duty with the 74-inch at the time, had the dome turned south and first received word by telephone at 9.24 p.m. On going outside the train was still visible and was plotted for another ten minutes.

About twenty reports of this object have been received and a very preliminary solution for its path places it over the northwestern end of Lake Huron at a height in the neighbourhood of 60 miles above the surface of the earth. The train showed a rapid southerly drift during the time it was visible. A disappointingly small number of observations of this very remarkable meteor have been received and an effort is now being made to secure additional information.

P. M. M.

REVIEW OF PUBLICATIONS

Essentials of Engineering Astronomy, by Jerry H. Service. Pp. ix + 165, 6 × 9 inches. New York, Prentice-Hall, Inc. 1937. Price $2.50.

The author of this book is on the staff of the Michigan State College of Mines and Technology; the purpose of the book is to outline the astronomical observations necessary to enable an engineer or geologist to personally map areas of unexplored country. The equipment used to obtain the required degree of accuracy is only a good transit, a watch, and a radio for time signals.

The first section deals with the astronomical fundamentals, starting with a very brief, fairly modern outline of descriptive astronomy, followed by a collection of the formulae of spherical trigonometry. The Celestial Sphere and Time are discussed in some detail, and then the various methods of determining latitude and longitude are outlined.

The second section forms a working manual of the methods of observation and computation involved both in actual map making and in the determination from sextant measures, of position at sea. The instructions throughout are precise and detailed.

F. S. H.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

Changes in the Lunar Craters Messier and Pickering

While it is well known that the surface of the moon appears to undergo no major variations, some astronomers believe they have detected minor changes in certain of the lunar features. Such changes are very difficult to observe because the whole appearance of lunar markings is dependent on the direction of illumination and the angle of sight of the observer.

Professor William H. Pickering has recently studied two small adjoining craters, designated Messier and W. H. Pickering, and suggests that they go through a cycle of changes of size and shape at each lunation. Following this work two observers, E. Martz, in Jamaica and Illinois, and Walter Haas, in Ohio, report that they have systematically observed and drawn these two craters during 1936, using various telescopes ranging in aperture from six to twelve inches. They found changes in the general distinctness of the craters, a possible twilight effect in the crater Pickering, and the development of bright and dark spots independently of the sun's altitude. Haas considers that these observations confirm Professor Pickering's suggestion that these are real physical changes. It should be remembered, however, that other astronomers have apparently been able to explain small lunar changes as variations in the reflection effects from various types and roughnesses of surface, with changing angles of illumination and observation.

Comets Finsler and Hubble

Since the June number of this Journal was issued, two new comets have been discovered. Unfortunately, both are now receding from the earth and sun, and are consequently becoming fainter.

The first of these was discovered as a seventh magnitude object by Professor Finsler, of Zurich, on July 4th. It rapidly increased in brightness to the fourth magnitude, and crossed the northern sky, passing through the handle of the Big Dipper on August 12th. To the unaided eye it has been an interesting though not spectacular

object. In the telescope a fairly sharp nucleus was observable, surrounded by a symmetrical head. The tail showed a complex and changing structure. During the coming month the motion of comet Finsler is chiefly south, as is indicated by the following brief ephemeris:

	R.A.	Dec.
Sept. 4	$14^m\ 08^m.6$	$+\ 1\ °48'$
16	14 12 .3	− 6 45
28	14 14 .8	−12 03
Oct. 10	14 17 .5	−15 54

By the latter date the comet will have disappeared into the sunset sky.

Hubble's comet is a much fainter object, of the thirteenth magnitude, discovered by Dr. E. P. Hubble of Mount Wilson Observatory, on August 4th. Preliminary orbits, from a very short arc, indicated that the comet would approach close to the earth at its perihelion next December. However, subsequent more precise orbits show that the comet has already passed its perihelion, and that this is an outlying object that apparently never has been bright or close to the earth.

The orbital elements of these two comets are as follows:

		1937*f* (Finsler)	1937*g* (Hubble)
Date of Perihelion Passage	T	1937 Aug. 15.77	1936 Nov. 10.46
Longitude of Perihelion	ω	114°.75	144°.73
Longitude of Ascending Node	Ω	58°.41	98°.40
Inclination of Orbit Plane	i	146°.34	11°.87
Perihelion Distance	q	0.8630	1.923

F. S. H.

June Report of Variable Star Observers, Toronto

Mr. Neill McNabb Jr.—4 observations on R Cor Bor
—7 searches for novae in 2 regions
Mr. Bert Topham —11 observations on 9 variables
—3 searches for novae in 2 regions.

Clouds and haze made a large percentage of the June evenings unfavourable for observations. Mr. Topham is to be specially commended for his variable star work. It takes considerable time

to identify a new star field, and most of the nine he worked on this month, he was observing for the first time.

F. Shirley Patterson.

Notes From the Dominion Astrophysical Observatory, Victoria, B.C.

In continuation of the observing statistics from the September, 1936 issue of the Journal, we have the following from the records of the observatory:

			18-year average	
1936	Nights	Hours	Nights	Hours
August	28	172	24	149
September	25	199	20	149
October	20	197	16	125
November	17	155	12	81
December	16	87	10	63
1937				
January	13	105	10	62
February	10	60	13	93
March	11	60	16	97
April	15	71	17	102
May	17	89	20	109

The year 1936 was the best for observing since the institution was opened but the year 1937 bids fair to be the worst. Up to the middle of January we had splendid weather for observing but since then the observing conditions have been much below the average, If this should catch the eye of Dr. DeLury of Ottawa would he please arrange to have the spots brushed off the sun, or at least have them sputter away from this locality.

Visitors to the observatory show a general increase though there has been no large influx of tourists as yet this summer, due partly to shipping troubles and tie-up of the ferries serving the Island. In August of last year 8,750 persons visited the place. Recently we had the pleasure of a fleeting visit from Dr. S. Herrick, Jr. who has been relieving Professor Jacobsen at the University of Washington, while the latter is in attendance at the University of California. Dr. Herrick has made a valuable contribution to radial velocity work in preparing tables to facilitate the reduction of the velocities of the sun.

Dr. Andrew McKellar of our staff paid a hurried visit to the Lick and Mount Wilson observatories while on vacation in March.

Dr. J. A. Pearce attended the meeting of the Royal Society in Toronto in May and presented the eleven papers from this institution to the Section on Mathematical and Physical Sciences. Later, Dr. Pearce visited at his old home in Mitchell, Ontario, before returning.

Dr. C. S. Beals, accompanied by Mrs. Beals, left to attend the Denver meetings of the American Association for the Advancement of Science held June 21-28. He is presenting a number of papers on behalf of members of the staff at the meetings of Section D on Astronomy. Dr. Beals is motoring and on his return will visit the Flagstaff, Mount Wilson and Lick observatories.

Mr. R. Meldrum Stewart, Dominion Astronomer, is expected to pay us a visit about the last week in June. He will stop off also at Saskatoon, Edmonton and Vancouver, spending a day at each place on official business.

The calls upon members of the staff for addresses upon astronomical topics continue, suggesting an ever increasing interest in astronomy by people in all walks of life. Dr. Pearce made a rapid round of the Canadian and Service Clubs in the interior of the Province last autumn, while your scribe did the same for the Island in December. Everywhere people were much interested and seemed to delight in asking numerous questions.

Supplementary Notes from the Dominion Astrophysical Observatory

The month of July was a very good one for observing. It was quite a good month from the tourist point of view also. Of course the astronomers are not particularly enamoured of tourists, especially if they overstay their allotted two hours on Saturday nights, thereby preventing one's own particular research work. However, at heart we are all glad to see people interested in our work and over 8,000 persons visited the place in July.

Among other groups were students from the various summer schools. There were 890 registered at the Victoria Summer School, many coming from the prairies. The Vancouver group had expected

to make the trip over but found it necessary to cancel arrangements. However, the Bellingham, Wash., Summer School chartered a boat for their annual outing to Victoria and between 200 and 300 learned a little about the institution.

Professor R. W. Wood of Johns Hopkins University accompanied by Mrs. Wood, spent a short time at the observatory on their way to the observatories of the southwestern United States. Professor Wood had ruled a grating for us last year on a croluminized base and he is very enthusiastic about the future of such gratings.

Professor C. H. Smiley of Brown University, Providence, R.I., is expected to pay a call and Professor L. C. Leonard of Los Angeles, who is exchanging for the Summer Session of the University with Dean Buchanan, is to give an address in Victoria on the 23rd August. He will likely spend a few days with us at that time.

Dr. R. M. Petrie plans to attend the meeting of the American Astronomical Society at Williamstown in September. He will be the only representative from this observatory and will present the seven papers from members of the staff.

The primary and secondary mirrors were resilvered about the middle of July and very satisfactory coatings were obtained.

The photometer which has been under construction for some time and which is to be used in conjunction with the 72-inch telescope is practically complete and seems to function well.

With the marked increase in the sun-spot activity there have been some fine auroral displays of late. Miss R. L. M. Jebb of Alberni, a hundred miles up the island, writes commenting on the aurora of the night of August 3rd—"Then there appeared in the east a ray of light like that of a broad searchlight, it gradually spread upwards in a beam and finally formed a complete arc of light, passing almost over head and down beyond the horizon, in the west, the arc was broken in three or four places by well-defined bands of darkness running obliquely across it. The whole bow moved slowly southwards. The arc was complete and at its brightest soon after 10 p.m. By 11 p.m. it had begun to fade and by midnight it had vanished." It was quite an unusual appearance, something similar being witnessed here. W. E. H.

POETRY, SCIENCE, PROSE

Clear definitions of poetry and prose, which would enable the reader to distinguish compositions said to be one or the other, are not in existence. Somewhat similar difficulties are met with in other branches of learning. Water is a liquid and wood is a solid but what are wax and tallow? The physicist has answered this question pretty satisfactorily to himself but the reason for his ability to do so is that in science the aesthetic sense or the personal feelings of the individual are not concerned as they are in literature.

In a recent number of the *Canadian Poetry Magazine* appeared a long poem entitled "Hunger". From it I give a short quotation and alongside an equal portion from a well known text-book on astronomy. Perhaps the reader will try to determine which is poetry and which prose. Also, are they both good science?

I

Not only can one or more
Electrons be removed from an atom,
In ionization,
But also a given atom or ion
Can be excited,
That is,
The position of one or more of its
electrons
Can be changed within the atom.

II

High priests of the new Baalim
Measure the orbit
Of neutrons and electrons in the atom,
Predict with precision
The effect of their union
Or sudden disintegration,
Release their primal energy
Potent to create or destroy.

Some fifty years ago there was a college text-book which taught that only certain words were properly usable in poetry,—that it should have a certain elevation of diction, simple though it might be. One can hardly look on 200-inch, or appendicitis, or hypergeometric series as suitable for such a purpose; but the boundary line cannot be drawn too closely. Our language and our tastes change with the passing years.

Prose may be distinctly poetic and yet be true prose, while some verse is certainly quite prosy. Let me give an illustration of the former. In H. E. Scudder's "James Russell Lowell: a Biography", the author when referring to a reprint of the first edition of Milton's "Areopagitica", for which the poet, then 71 years old, wrote an

introduction, quotes a few sentences of Lowell's characterization of Milton's prose, as follows:

> He must have known, if any ever knew, that even in the 'sermo pedestris' there are yet great differences in gait, that prose is governed by laws of modulation as exact, if not so exacting, as those of verse, and that it may conjure with words as prevailingly. The music is secreted in it, yet often more potent in suggestion than that of any verse which is not of utmost mastery. We hearken after it as to a choir in the side chapel of some cathedral heard faintly and fitfully across the long desert of the nave, now pursuing and overtaking the cadences, only to have them grow doubtful again and elude the ear before it has ceased to throb with them.

Perhaps one more illustration may be offered,—this time from Alfred Noyes' "The Torch-Bearers". Some portions of his poem on "Kepler" might well be printed as prose:

> John Kepler, from the chimney corner, watched his wife Susannah, with her sleeves rolled back making a salad in a big blue bowl. . . . "Look, John," said she, "What beautiful hearts of lettuce! Tell me now how shall I mix it? Will your English guest turn up his nose at dandelion leaves as crisp and young as these? They've just the tang of bitterness in their milk that gives a relish and makes all sweet; and that's philosophy, John. Now—these spring onions! Would his Excellency like sugared rose-leaves better?" "He's a poet, not an ambassador [Sir Henry Wotton] only, so I think he'll like a cottage salad". . . . . "John, I'm afraid!" "Afraid of what, Susannah?" "Afraid to put those ducklings on to roast. Your friend may miss his road".

And so on. But a hundred lines later the mystical astronomer bursts into unmistakable poetry. He had published a work entitled "Harmonices Mundi" (Harmonies of the World) and he is made to say:

> All that the years discover points one way
> To this great ordered harmony, he said,
> Revealed on earth by music. Planets move
> In subtle accord like notes of one great song
> Audible only to the Artificer,
> The Eternal Artist. There's no grief, no pain,
> But music—follow it simply as a clue,
> A microcosmic pattern of the whole—
> Can show you, somewhere in its golden scheme,
> The use of all such discords; and, at last,
> Their exquisite solution. Then darkness breaks
> Into diviner light, love's agony climbs
> Through death to life, and evil builds up heaven.

Have you not heard, in some great symphony,
Those golden mathematics making clear
The victory of the soul? Have you not heard
The very heavens opening?
Do those fools
Who thought me an infidel then, still smile at me
For trying to read the stars in terms of song,
Discern their orbits, measure their distances,
By musical proportions? Let them smile,
My folly at least revealed those three great laws;
Gave me the gold vases of the Egyptians,
To set in the new temple of my God
Beyond the bounds of Egypt.

There is much more of the same high quality.

SUMMER PICKINGS

It may truly be said that Lowell had now found himself, and that from this period dates the full orbit of a course which had heretofore been more or less eccentric, but now could be reasonably calculated. (Scudder's "James Russell Lowell: a Biography").

. . . . .

The conscious intention to be original, he himself says, seldom leads to anything better than extravagance . . . that the way to be original is to be healthy; that the fresh colour, so delightful in all good writing, is won by escaping from the fixed air of self into the brisk atmosphere of universal sentiments; and that to make the common marvellous, as if it were a revelation, is the test of genius. (*Idem,* ii, 88)

. . . . .

Writing from Weimar, Lowell says: "The water [of a river in the park] is so clear as to seem almost luminous, the water-mosses are as green as those of the sea, and some horse-chestnuts that had fallen in shone like live coals". (*Idem,* ii, 271) Were the chestnuts luminescent? Recall the beautiful experiments with chestnut bark in violet light.

. . . . .

There is in manufacturing a creative joy that only poets are supposed to know. Some day I'd like to show a poet how it feels

to design and build a railroad locomotive.—*Walter P. Chrysler.*

How about the feelings of an astronomer who has completely built a large telescope (say, a 19-inch reflector)—including the mirror, the mounting and also done all computations and testing?

. . . . .

Life at an English school about 1850: "Hands, face, 'and perhaps the neck', were washed daily; feet once a fortnight, heads as required; a vernal dose of brimstone and treacle purified their blood, a half-yearly dentist drew their teeth, it was the custom under flogging to bite the Latin Grammar."—*G. M. Young* in "Victorian England: Portrait of an Age", p. 96.

C. A. C.

MEETINGS OF THE SOCIETY

AT VICTORIA

February 3, 1937.—The first meeting of the year was held at the Y.W.C.A. parlors with President Shaw in the chair. The president called upon Miss Oliphant, the Librarian, to give a report. Additions to the library were mentioned and various volumes were described and recommended to the members. The vice-president, Mr. Robert Peters, spoke upon the use of the HANDBOOK for the current year. A problem involving the use of the HANDBOOK was proposed for the pleasure and edification of the membership. Mr. F. A. Lindsay was elected to membership in the Society.

The lecture of the evening,—"Copernicus, the First Modern Astronomer" was given by Miss Phoebe Riddle, B.A. The speaker introduced her subject with a vivid word picture of the condition of scientific knowledge and outlook in the 16th century. A description of the Ptolemaic system of cosmology with its epicycles and deferents served to emphasize the great achievement of Copernicus in establishing the heliocentric viewpoint. The life and activities of the astronomer were then described, leading to the culmination of his work in the publication of "de Revolutionibus", a copy of which was received by the author just before death. This biographical sketch was followed by a discussion of the arguments and proofs employed by Copernicus in establishing his theory and a summary of its subsequent triumphs. The speaker closed with a discussion of the great influence of Copernicus upon scientific and philosophical thought. At the close of the lecture a hearty vote of thanks was given to Miss Riddle for her interesting and instructive speech.

February 24, 1937.—The meeting was called to order at 8 p.m., President Shaw being in the chair. Two new members were elected to the Victoria Centre, Mr. James Smith and Mr. John C. McDonald, (Jr. member).

The vice-president, Mr. Peters, spoke briefly on certain variable stars and telescopic objects now in the night sky, and gave the solution of a problem in practical astronomy. Following this, Mr. W. F. Holdridge was presented with the prize he won in the recent essay contest. In receiving this Mr. Holdridge very generously returned this award to the society to be presented to the amateur giving the best 15 minute talk in the summer course.

The President then introduced the speaker of the evening the Rev. Robert Connell, who addressed the society on the subject "Fossil Weather". Mr. Connell began with a description of the geological method of fixing the time scale from evidences found in various rocks and their associated fossil remains. The climate conditions of ancient times were shown to be revealed by the rocks themselves and by the fossilized flora and fauna found therein. The speaker then went on to describe the various climates which prevailed over Vancouver Island during geological time, and told of his own researches and discoveries in the neighbourhood of Victoria. The interest of the lecture was heightened by reference to local configurations and deposits of geological significance. The

lecture was illustrated by various specimens which were inspected by the members.

March 17, 1937.—The meeting was called to order at 8 p.m. with President Shaw in the chair. Lester Hamlin was elected to membership.

The president then called upon Dr. C. S. Beals to address the society upon the topic, "The End of the World". The lecturer first gave a résumé of legends and prophesies regarding the end of the world, from mythological times to the present century. Destruction by fire, flood, cold, earthquake, draught and celestial causes was described. Various specific instances of recorded predictions were retailed to the entertainment of the meeting.

Following this introduction Dr. Beals discussed the astronomical and geological evidences regarding the termination of the earth's habitability. The material was presented under four headings *viz:*

(1) Atmospheric loss and changes,
(2) Orbital perturbations,
(3) Tidal friction and Earth-Moon system,
(4) Changes in solar radiation.

The lecturer came to the conclusion that although human tenure of the globe is not indefinitely long, a very great period of time (10^9-10^{10} years) is available.

At the end of the lecture a very hearty vote of thanks was tendered Dr. Beals for his very enjoyable and informing lecture. The meeting adjourned at 9:30 p.m.

April 7, 1937.—The meeting came to order at 8 p.m., with President Shaw in the chair. Mr. H. K. Bates was elected to membership. A meeting of the Telescope Making Section was announced for April 16, subsequent meetings to be held on the first and third Fridays of each month.

Mr. R. Peters, the vice-president described some of the spring constellations containing objects of special interest such as double and variable stars. The approach of sun-spot maximum and the coming transit of Mercury were discussed. The members of the society were informed of an excellent opportunity of seeing Mercury with the unaided eye.

The president next called upon Mr. Wallace of Victoria College to address the meeting upon "The Life and Works of Descartes". The speaker first gave a summary of Descartes' early life and education describing the development of the young sceptic and philosopher, then went on to discuss his life as a soldier and his travels about Europe. In early middle-age Descartes was in correspondence with all the leading intellectuals of Europe and had acquired a reputation of profound learning before he reached the age of 40. His book, which was destined to exert a great influence over modern science and mathematics, was published in 1637, the author then being 41 years of age. His later life was spent in Holland and Sweden and in the latter country Descartes died at the age of 54 years.

The last part of the lecture was devoted to a description and appraisal of the work of Descartes. His invention of the method of analytical geometry places him among the first half-dozen greatest mathematicians. J. S. Mills calls it

"the greatest single step in Science" and Bell says "Modern Mathematics began with analytical geometry (1637) and the calculus (1667)." The lecture was illustrated with numerous blackboard examples and at its close the meeting tendered Mr. Wallace an unanimous vote of thanks for his interesting lecture.

April 28, 1937.—The meeting was called to order at 8 p.m., with President Shaw in the chair. The minutes of the previous meeting were read and approved. It was announced that the Telescope-Making section would meet every Friday. The secretary spoke briefly on "The Harvest Moon" in answer to a query in the question box.

The chief business of the meeting was a symposium on the "Cultural and Practical Benefits of Astronomy", the discussion being led by three of the members. The President called upon Mr. P. H. Hughes to discuss certain cultural aspects. Mr. Hughes directed the attention of the audience to the value of astronomical studies in giving a sense of relative values. Ideas of Eternity, the Creator and the relative values of things assume proper proportions in the light of astronomical knowledge. The points were illustrated by apt quotations from the poets, the Bible and the Press.

The next speaker, Commander Tingley, discussed some of the practical results of astronomy. After mentioning methods of surveying, time-keeping and tidal predictions, and date-recording, he proceeded to describe the methods of using astronomical observations for the determinations of latitude and longitude and the method of locating position at sea.

The third speaker, Captain Everall, spoke on the usefulness of astronomical studies in forming a philosophical view of life. The appearance of the night sky and natural procession and succession of celestial apparitions lead one to rise above his "earthy" environment. Quotations from Longfellow and Matthew Arnold illustrated the philosophical influence of astronomy.

The thanks of the meeting were returned to Messrs. Hughes, Tingley and Everall for their interesting presentations. Some interesting discussion by members of the society followed.

May 19, 1937.—The meeting came to order at 8.15 p.m. with President Shaw in the chair. The minutes of the previous meeting were read and approved. Mr. G. A. Burgess was elected to membership in the Society. Mr. Robert Peters spoke briefly upon the summer planets and constellations and some interesting variable stars.

The President then called upon Mr. K. O. Wright to address the meeting upon the subject of meteors. The speaker began with a description of the methods of meteor observation and the information obtained from such data. An interesting survey of meteor falls from ancient times to the present century was presented. The spectacular history of the Leonids, or November meteors was described and explained in detail. The lecturer continued with descriptive and explanatory matter regarding observations and theories concerning meteors in general. Lantern slides and actual samples of meteoric material were exhibited and noted. A plan for the cooperative observing of the Perseids was proposed, the membership showing interest in this amateur activity.

At the close of the meeting a hearty vote of thanks was returned to Mr. Wright for the interesting presentation. Announcements were made regarding the forthcoming summer course and Mr. Brydon's radio talk.

R. M. PETRIE, *Secretary.*

AT VANCOUVER

May 11, 1937.—The 48th regular meeting was held on Tuesday, May 11th, and was preceded by the annual dinner at Union College, where 14 members sat down to an enjoyable meal. Mr. Newton presided.

After dinner the meeting moved to the Science Building. Mr. Newton then gave an account of the life and work of the late Rev. W. F. A. Ellison, Director of Armagh Observatory, who died on the 31st December last, and with whom Mr. Newton was personally acquainted in early life.

Mr. Ellison was born in 1864, graduated at Trinity College, Dublin, and after some years in England occupied various livings in Irish parishes. His early interests included clocks, thermometers and telescopes. Telescopes becoming his special avocation, he became expert in the making of parabolic mirrors and objectives. He produced over 140, mostly mirrors, of fine quality, during his long active life.

In 1918 he was appointed Director of Armagh, on which he lavished his energy and technical skill to the great improvement of the Observatory. In 1920 he published his work on Amateur Telescope Making on which the Scientific American Company founded its series of A.T.M. books. During all this time Mr. Ellison continued his work with the Church, holding a number of appointments. Active to the last, he attended the total eclipse of the sun in the Mediterranean area last year. Through the worth to amateurs of his publications and the inspirational value of his life, Mr. Newton named him the "father of Amateur Telescope Making."

The meeting then took up a discussion of ways and means of improving the Centre's appeal to members and public. Mr. Newton thought practical work, for example, variable star and meteor observation, should stimulate interest. Mr. Jorgensen stressed the need for young members and a place for them to meet. Mr. McDonald advocated wider publicity through daily and local advertising papers, the formation of local clubs, possibly in connection with high schools, and the inclusion of astronomy in the high school curriculum. Mrs. Anderson drew on experience with the Vancouver Natural History Society, which had many school teachers in its membership, and made weekly summer excursions, holding its winter meetings in a down-town school auditorium. Mr. Fowler stated that astronomy is included in the high school curriculum under general science. He suggested, as adjuncts to the Centre, shop, tools and library. Mr. Stewart thought meetings held down town would draw larger audiences. Dr. Ure agreed with the idea of local clubs. He thought the interest of winter meetings would be increased by limiting each season's programme to some definite phase of astronomical study—planets, for instance, in one season. He suggested a committee to foster a school campaign. Mr. Thrupp proposed that notices

of meetings be posted in high schools and endorsed in part the study type of programme.

J. Teasdale favoured attracting youth, but warned that the student's interest already covered a wide field and that astronomy is relatively remote from daily life. Interest of high school teachers in the Centre's activities appeared to be transient, 3 early members of this class being lost. He was unable to see how we would supply speakers for local club meetings when we have some difficulty filling our own programmes. He noted the interest at this meeting, manifest in the number of suggestions, and compared it with the indifferent record of attendance at meetings in the past, holding that the ordinary member can, at least, contribute to the success of the organization by attending its meetings.

It was decided that the Council meet to deal with the proposals made at this meeting.

J. TEASDALE, *Secretary.*

AT MONTREAL

Summary of minutes of the Centre for the 1936-37 season.

October Meeting.—Annual reports were read and election of officers took place. Dr. A. Vibert Douglas gave a lecture on Recent Investigations of the Milky Way. The new atlas of F. E. Ross and M. Calvert was on view and the speaker discussed the photographic work which has been done on the reflection nebulae and on the polarization of light from nebulae.

November Meeting.—A report on Summer Observations was made by Mr. F. De Kinder. Every Thursday from the end of May until the end of October (or if wet or cloudy, on Friday) one or more members of the Telescope Committee set up instruments on the roof of the Sun Life Assurance Co. of Canada on Dominion Square where members of the R.A.S.C. and their friends came and viewed planets, moon, binaries, clusters, etc.

Mr. Geo. Harper Hall reported on the new lens for the six-inch refractor which was ordered from London.

January Meeting.—Dr. D. H. Menzel of Harvard Observatory lectured on the Harvard-M.I.T. expedition to Ak Bulak, Southern Siberia, to view the 1936 Solar Eclipse. His descriptions of the equipment, the co-operation of the Russian authorities, and the scientific results were much appreciated.

February Meeting.—Three members of the Centre gave brief addresses; one member reported upon the Annual Meeting in Toronto, another described the Galaxy. A good number of Boy Scouts were present to hear Mr. E. Russell Paterson lecture upon Planets.

April Meeting.—Dr. Peter Millman of the David Dunlap Observatory delivered an excellent lecture upon Meteors. He described the methods of investigation and the resulting information regarding the numbers, sizes, families, brightness, velocity, composition, height and spectra; also the inferences regarding our own atmosphere and regarding the cosmic origin of fast moving meteors.

Members were invited to attend the last meeting of the McGill Physical

Society when Dr. Chas. Hendel, Professor of Philosophy at McGill University, lectured upon The Interrelation of Philosophy and the Sciences.

At all the regular meetings of the Society the President, Mr. Henry F. Hall, was in the Chair; and, by courtesy of the Director of the Macdonald Physics Department, the meetings were held in the Physics Lecture Theatre.

A. VIBERT DOUGLAS, *Secretary.*

AT HAMILTON

HAMILTON CENTRE'S FIELD NIGHT

The annual field night of the Hamilton Centre was held on June 15th on the spacious grounds of Mr. Walter T. Goddard, who is vice-president of the Centre, and acted as host for the occasion.

Mr. Goddard's lovely garden was converted for the evening into a veritable bee-hive of what were conservatively estimated as 1200 astronomical bees who turned out to see the Moon, Mars, Jupiter and more distant objects through the telescopes erected for the occasion by the members of the Hamilton Centre. The honey consisted of coffee, cakes and cookies supplied by the host's family who were kept busy till well after midnight catering to the throng. While Mrs. Goddard had made plans to accommodate all comers she showed ingenuity in satisfying at least twice as many as had been anticipated without let or hindrance. She must have had the keys of all the bakeshops in the vicinity, the delicacies from which were commandeered no doubt in the order of their proximity until all had been served. Misses Phyllis and Beryl Goddard and their willing friends found the work so pressing that their brothers Walter, Jr. and Dick Goddard were reduced by the exigency of the circumstances to spending the evening over the dish-pan.

Professor A. E. Johns, the president, pointed out the conspicuous stars, addressing the multitude at intervals through a megaphone while they were waiting patiently for their turns at the eyepieces of the twelve telescopes manned by members of the Centre. This spontaneous gesture of the president who realized that something was needed to keep the crowd in good humor proved at once instructive and entertaining.

Alderman John Marsh, M.P. was in charge of Mr. Goddard's clock-driven 5-inch refractor. The other telescopes ranged from 8-inch reflectors to 2½-inch refractors. Some of these were built by amateurs living in Hamilton and its vicinity and were manned by W. S. Mallory, E. G. Freeman, T. H. Wingham, G. E. Campbell, Dr. W. Findlay, P. H. Butcher, J. S. Taylor, E. E. Bossence, O. Paton, N. Green, H. Fox, G. Larn, C. Mason, O. Nelson and Mr. and Mrs. S. W. Scammell.

Due to a combination of circumstances, including a perfect night, splendid publicity with the co-operation of the "Hamilton Spectator" and Mr. Goddard's inviting estate, this was a red-letter day in the annals of the Hamilton Centre and the thanks of the Society are extended to all who aided in the evening's activities and especially to Mr. and Mrs. Goddard for their kind hospitality.

N. H. BROADHEAD, *Secretary.*

AT OTTAWA

Jan. 28, 1937.—"Russia—In and Out of Eclipse" was the title of the address given by Dr. D. H. Menzel of Harvard University before the members and friends of the Ottawa Centre of the R.A.S.C. in the Lecture Hall of the Royal Victoria Museum. Mr. John McLeish, Director of Mines of the Department of Mines and Resources, and president of the local centre, introduced the speaker. He mentioned that though but a young man, Dr. Menzel had already achieved a brilliant career as an astronomer.

In dealing with the "In Eclipse" phase of his topic, Dr. Menzel expressed hearty praise for the way in which people both in United States and in Russia assisted to the best of their ability in making the whole venture a success. It was a big venture, involving 10 tons of equipment and 22 persons, all to be transported thousands of miles to the astonished town of Ak Bulak in Asiatic Russia. With motion pictures and still pictures, the speaker described the difficulties due to high wind and dust. The last minute frantic preparations were accompanied by the fear that all would be lost due to cloudy weather. But nature combined with the efforts of men to make the great venture a success. The clouds cleared sufficiently to expose the sun in all the glory of the eclipse. The party sponsored jointly by Harvard College and the Massachusetts Institute of Technology was one of the few so favored. Dr. Menzel, leader of the expedition made visual observations with a small telescope, and thus for the first time saw an eclipse. In the other four expeditions he has attended, he had been too busy with instructions to look up. The corona was very much brighter in this eclipse than in others attended by Dr. Menzel, and it was also noted that the prominences on the sun's surface were bluish or lavender rather than red. Excellent spectrographic results were obtained, and in particular, a prominent line in the green region was noted.

In speaking of "Russia out of Eclipse", Dr. Menzel said he was very favorably impressed with the intelligent manner in which the present Russian leaders were attempting to solve their problems.

There was a discussion period after the lecture during which Dr. Menzel answered questions from the audience.

M. M. THOMSON, *Secretary.*

MEMBERS AT LARGE

Elected since those listed in the March issue.

ANDERSON, CHAS. A.—214 E. College St., San Angelo, Texas, U.S.A.
AGUILAR-SANTILLAN, PROF. DR. R.—Justo Sierra No. 19, Mexico, D.F., Mexico.
BEIDLER, HERBERT B., A.I.A.—952 N. Michigan Ave., Chicago, Ill., U.S.A.
BRYANT, PAUL E.—Marmet, West Virginia.
BLISS, ALFRED V.—41 Phillips St., Wollaston, Mass.
DENNY, J. HOWARD—Scruggs-Vandervoort-Barny Inc., St. Louis, Mo.
DEL RIO, HECTOR M.—Edificio Andian, Cartagena, Colombia, S.Am.
ERICKSON, CLAUD R.—1509 W. Washtenaw, Lansing, Mich.
GOERGEN, REV. J. J.—Marist Novitiate, Prince Bay, L.I., New York.
GRANDMONTAGNE, LEO F.—351 Coitsville Road, Youngstown, Ohio.
HAGEN, ELLIS H.—135 N. 6th Avenue, Highland Park, N.J.
HAMMOND, CHAS.—1004 N. Howard St., Glendale, Calif.
HEILIG, JAS. L.—2225 N.E. 26 Ave., Portland, Oregon.
HOFFMASTER, THOMAS H.—1051 Pope Avenue, Hagerstown, Maryland.
KLEIN, EMIL—7234 Algon Ave., Philadelphia, Pa.
MAHLMAN, WM.—44 Courier Blvd., Kenmore, N.Y.
MCCALL, A. C.—330 S. Kalorama St., Ventura, Calif.
MILLER, SAMUEL A.—Broadway, West Newton, Pa.
MOREHOUSE, HOWARD—553 St. Clair Rd., Grosse Pointe, Mich.
NELSON, WILLIS H.—310 S. Grand Avenue, Bozeman, Mont.
PATTERSON, W. T.—108 Wyndham St., Guelph, Ont.
OTTE, W. CLARKE—Realty Building, Louisville, Ky.
SCHEEL, ERIC—814 Birks Building, Vancouver, B.C.
SKEER, R. T.—15998 Nela Crest Ave., Cleveland, Ohio.
TRUESDELL, ARTHUR L.—Bernardston, Mass.
UPJOHN, L. N.—1556 Long Road, Kalamazoo, Mich.
WATERBURY, J. H.—6968 Owen Avenue, Chicago, Ill.
WHITE, JULIUS—121 E. Ohio St., N.S. Pittsburgh, Pa.
WHITEFORD, ANDREW L.—c/o McKinnon, Mackenzie & Co., Calcutta, India.
WILLIS, W. J.—24824-89th Avenue, Bellerose, N.Y.
ZIMMERMAN, WALTER W.—1683 Country Club Drive, Glendale, Calif.

The Royal Astronomical Society of Canada

OFFICERS FOR 1937

Honorary President—The Hon. Leonard J. Simpson, M.D., Minister of Education for the Province of Ontario.
President—R. E. DeLury, M.A., Ph.D., Ottawa.
First Vice-President—Wm. Findlay, Ph.D., Hamilton, Ont.
Second Vice-President—J. A. Pearce, M.A., Ph.D., Victoria.
General Secretary—E. J. A. Kennedy, 198 College St., Toronto.
General Treasurer—J. H. Horning, M.A., Toronto.
Recorder—R. H. Combs, Toronto.
Librarian—P. M. Millman, Ph.D., Toronto.
Curator—R. S. Duncan, Toronto.
Council—D. S. Ainslie, M.A., Ph.D., Toronto; S. C. Brown, Toronto; F. Napier Denison, Victoria, B.C.; Miss A. Vibert Douglas, Ph.D., Montreal; E. A. Hodgson, M.A., Ph.D., Ottawa; Dr. G. R. Magee, London, Ont.; J. E. Maybee, Toronto; A. Thomson, M.A., Toronto; L. A. H. Warren, M.A., Ph.D., Winnipeg; and Past Presidents—Sir Frederic Stupart; C. A. Chant, M.A., Ph.D., LL.D.; A. T. DeLury, M.A.; J. S. Plaskett, D.Sc. F.R.S.; A. F. Miller; J. R. Collins; W. E. W. Jackson, M.A.; R. M. Stewart, M.A.; A. F. Hunter, M.A.; W. E. Harper; D.Sc.; H. R. Kingston, M.A., Ph.D.; R. K. Young, B.A., Ph.D.; L. Gilchrist, M.A., Ph.D., and the presiding officer of each Center.

TORONTO CENTRE

Honorary Chairman—Dr. C. A. Chant
Chairman—E. J. A. Kennedy
Vice-Chairman—S. C. Brown
Secretary—F. L. Harvey, 80 Gates Ave.
Recorder—Miss F. S. Patterson
Treasurer—J. E. Maybee
Curator—R. S. Duncan
Council—Dr. D. S. Ainslie; Dr. L. Gilchsirt; Dr. F. S. Hogg; J. H. Horning; T. H. Mason; Dr. P. M. Millman; Rev. C. H. Shortt; Dr. R. K. Young; and past Chairmen—A. F. Miller; A. F. Hunter; J. R. Collins; and A. R. Hassard

OTTAWA CENTRE

Honorary President—A. H. Miller, M.A.
President—John McLeish, B.A.
First Vice-President—Miss Miriam S. Burland
Second Vice-President—Francis Wm. Matley
Secretary—Malcolm M. Thomson, B.A.
Council—Miss Peggy Whitehurst; Karl Buckthought; A. H. Swinburn; W. W. Nichol, B.A.; T. L. Tanton, Ph.D.; and past presidents, R. Glenn Madill, B.A.; J. S. Lane, B.A., and C. C. Smith, B.A.

MONTREAL CENTRE

Honorary President—Mgr. C. P. Choquette
President—Henry F. Hall
First Vice-President—Dr. Julian C. Smith
Second Vice-President—Dr. F. D. Kinder
Secretary-Treasurer—Dr. A. Vibert Douglas, McGill University
Council—Dr. A. N. Shaw; Geo. H. Lighthall; G. Harper Hall; Dr. L. V. King; Col. W. E. Lyman; O. A. Ferrier; E. Russell Paterson; J. Addison Reid; Dr. C. C. Birchard

LONDON CENTRE

Honorary President—Dr. H. R. Kingston
President—J. C. Higgens
Vice-President—D. M. Hennigar
Secretary—Dr. G. R. Magee, 427 William St.
Treasurer—Mrs. Alice Davies
Council—Miss N. Morris; Miss S. Livingstone; T. C. Benson; W. L. Scandrett; Rev. H. E. Foucar; and Past President, Major E. H. Anundson

WINNIPEG CENTRE

Honorary President—Dr. J. S. Plaskett
President—W. H. Darracott
Vice-President—J. H. Kolb
Secretary—G. P. Morse, 3rd floor, Customs Building
Treasurer—R. D. Colquett
Council—M. F. Bennett; L. T. S. Norris-Elye; W. R. Junkin; H. P. Stokes; Mrs. A. S. Willis; and Past President A. V. Piggott

VICTORIA CENTRE

Honorary President—H. Boyd Brydon
President—Gordon Shaw
Vice-President—Robert Peters
Secretary-Treasurer—R. M. Petrie, Ph.D.
Librarian—Miss Mira Oliphant
Council—W. R. Hobday; L. Hopkins; A. McKeller, Ph.D.; W. Petrie; Miss P. Riddle; K. O. Wright, M.A.

HAMILTON CENTRE

Honorary President—Mrs. D. B. Marsh
President—Prof. A. E. Johns
Vice-President—T. H. Wingham
Second Vice-President—Geo. Campbell
Third Vice-President—W. T. Goddard
Curator—T. H. Wingham
Secretary-Treasurer—N. H. Broadhead, 15 Mapleside Avenue
Council—E. E. Bossence; G. Freeman; Dr. W. Findlay; H. Fox; J. A. Marsh; W. S. Mallory; Rev. E. F. Mainsell; Mrs. S. W. Scammell; J. S. Taylor

VANCOUVER CENTRE

Honorary President—Dean D. Buchanan
President—H. P. Newton
First Vice-President—Mrs. Laura Anderson
Second Vice-President—Seto More
Secretary—J. Teasdale, 4618 12th Avenue West
Treasurer—A. Outram
Council—H. R. Acton; G. E. Frostrup; H. W. Fowler; J. C. Jorgensen; M. A. McGrath; J. W. Moore; D. L. Shaw; F. R. Stewart; E. C. Thrupp

EDMONTON CENTRE

Honorary President—J. W. Campbell, M.A., Ph.D.
President—J. G. Taylor
Vice-President—C. G. Wates
Secretary—Prof. E. S. Keeping, University of Alberta
Treasurer—E. N. Higinbotham
Council—Miss M. O. Buchanan; Mrs. E. R. Clindinin; J. A. McLean; Dr. J. R. Tuck; F. S. Simpson

CALGARY CENTRE

President—Harold C. King
Vice-Presidents—H. J. Rees
Secretary-Treasurer—G. Finlay Moore, 3206 Vercheres St.

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

This Society was incorporated in 1890 under the name of The Astronomical and Physical Society of Toronto, and assumed its present name in 1903.

The Society has active Centres in Montreal, P.Q.; Ottawa, Toronto, Hamilton, and London, Ont.; Winnipeg, Man.; Edmonton, Alta.; Vancouver and Victoria, B.C.

The Society publishes a monthly JOURNAL containing each year about 500 pages and a yearly OBSERVER'S HANDBOOK of about 80 pages. Single copies of JOURNAL or HANDBOOK are 25 cents.

Membership is open to anyone interested in astronomy. Annual dues, $2.00; life membership, $25.00. Publications are free to members, or may be subscribed for separately. Apply to the General Secretary, 198 College St., Toronto, or to the local secretary of a Centre.

Extract from the By-Laws: Candidates who are elected to membership will be attached to a particular Centre, or to a section known as *Members at Large*. Members of the Society who live outside of Canada, or in a province in which there is no Centre of the Society will be considered *Members at Large* and not attached to any particular Centre, unless these members are expressly nominated for membership and attachment to a particular Centre. Members may be transferred from one Centre to another, or to the section *Members at Large* by the Council of the Society if written application for such transfer is made by such member to the Council.

The Society has for Sale:

Reprinted from the JOURNAL of the Royal Astronomical Society, 1936-1937.

The Physical State of the Upper Atmosphere, by B. Haurwitz. Pages 96; Price 50 cents postpaid.

Telescope Mountings for Amateur Builders, by H. Boyd Brydon, 48 pages; Price 25 cents postpaid.

General Instructions for Meteor Observing, by Peter M. Millman, 18 pages; Price 10 cents postpaid.

General Index to the TRANSACTIONS of the R.A.S.C., 1890-1905, and the JOURNAL, Vols. 1 to 25, 1907-31.

Compiled by W. E. Harper, Assistant Director, Dominion Astrophysical Observatory, Victoria, B.C., 122 pages, Price $1.00 postpaid.

Send Money Order to 198 College St., Toronto.